Adhesion measurements of thin film structures

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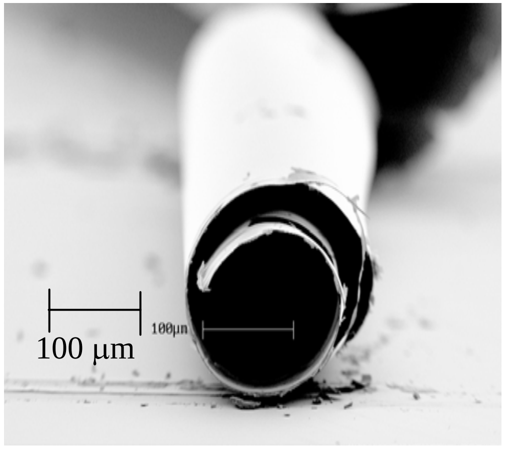
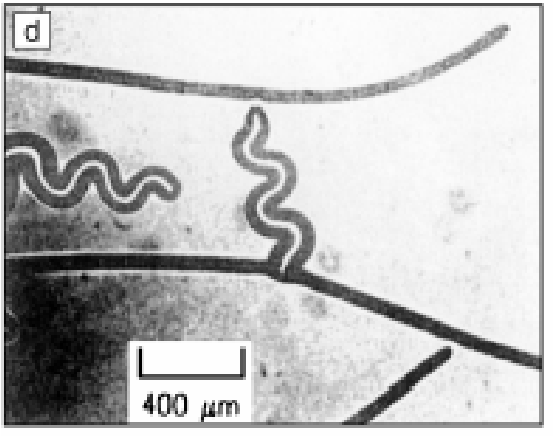
Adhesion of thin film structures (interconnects, packaging, MEMS, etc.) is a serious reliability issue due to:

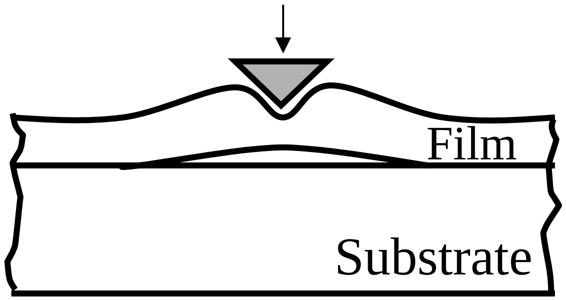
- High film stress (thermal expansion mismatch between film and substrate)
- Low/non reactive heterogeneous interface (metal/ceramic, organic/ceramic)
- High defects in films or along interfaces





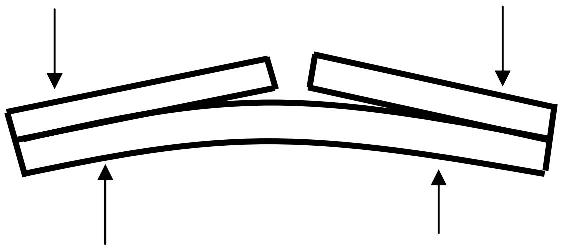
(Cook and Suo, MRS bulletin, 2002, p.45)

Thin film adhesion testing methods



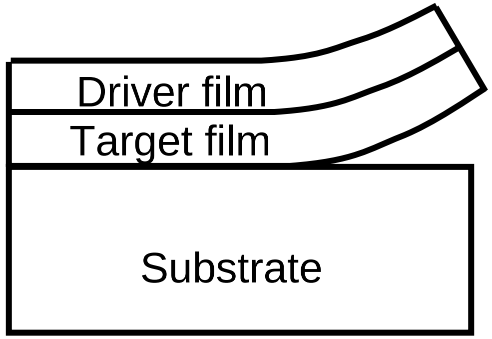
Indentation:

Volinsky, Moody and Gerberich, Acta Mater., 2002.



4 point bending

Dauskdart, et al., Eng. Frac. Mechanics, 1998

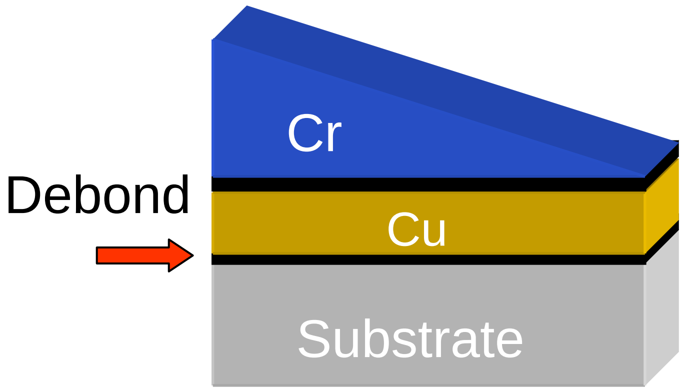


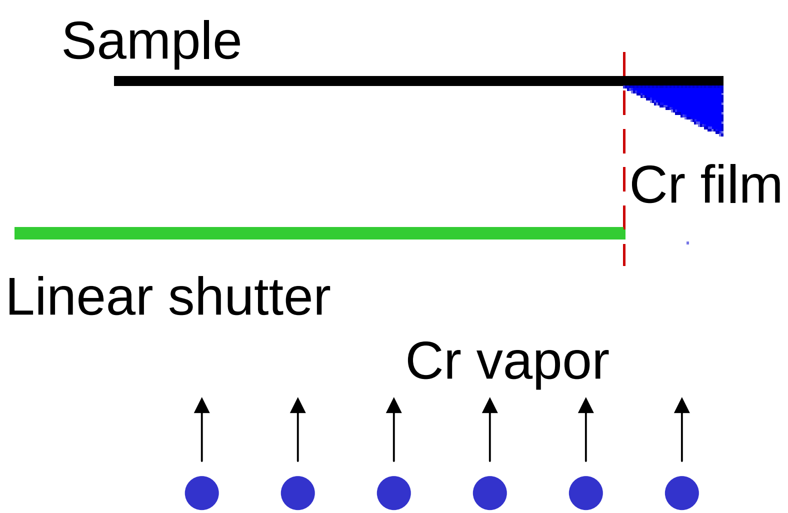
Driver film/superlayer method

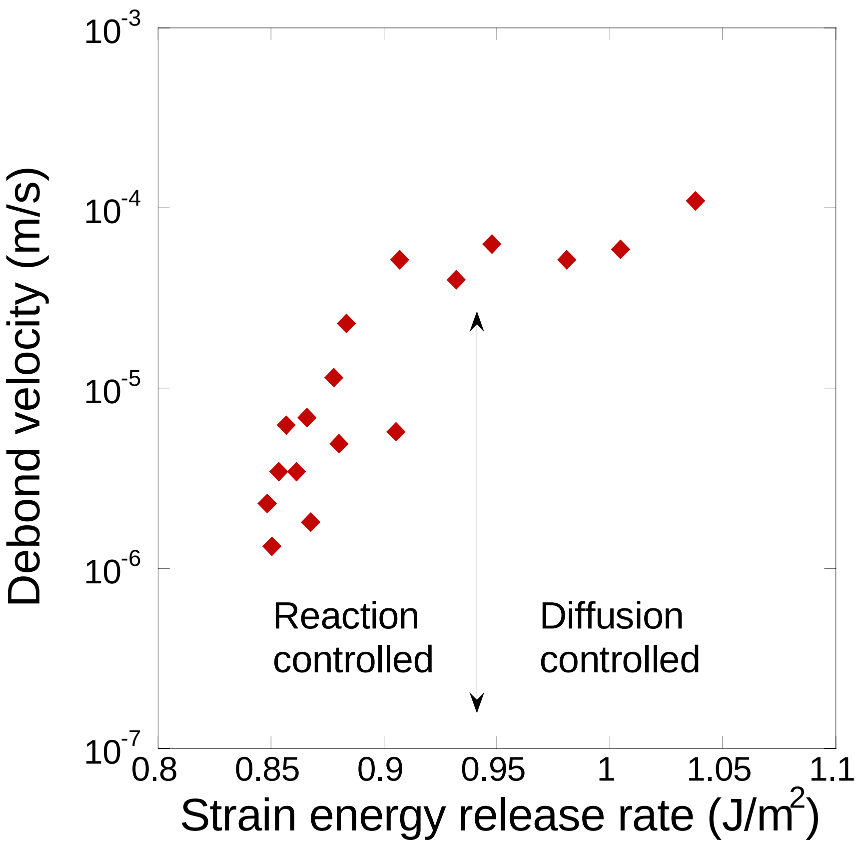
Bagchi, et al., JMR, 1994.

Driver film method to study adhesion

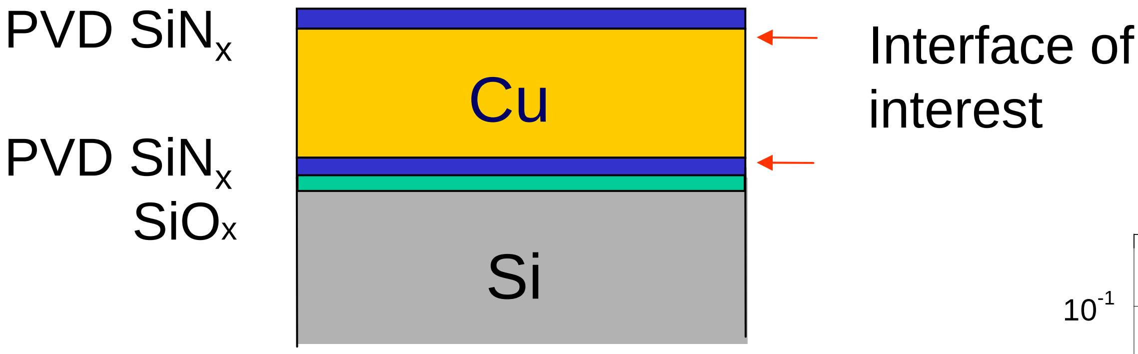
Quantitative, subcritical delamination







Effect of interfacial oxygen on adhesion

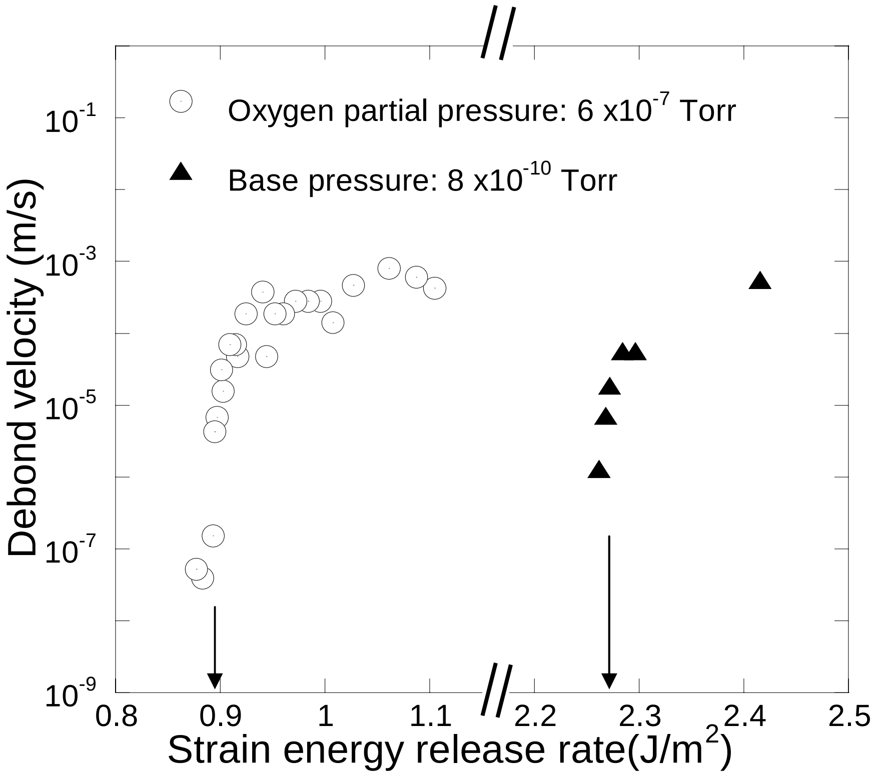


- Sputtered Cu (500nm):

  Two sets of depositions:

  ✓ UHV base pressure: 5×10^{-10} Torr

  ✓ Oxygen partial pressure: 6×10^{-7} Torr

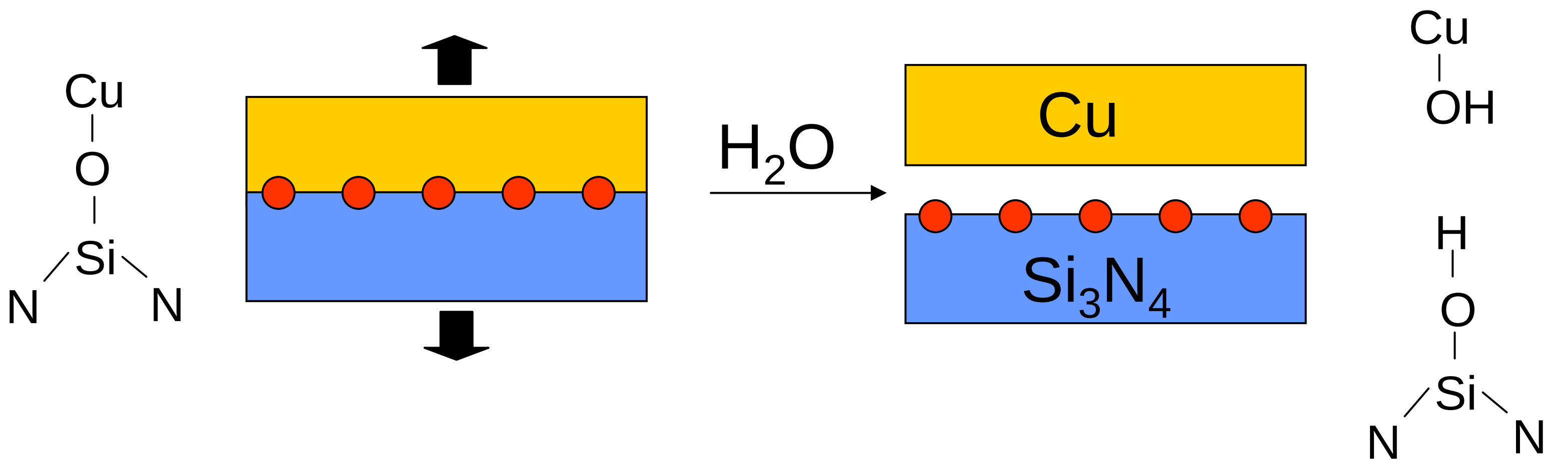


Less than one monolayer of oxygen segregated to Cu/SiN_x interface, participating in Cu-O bonding – SIMS, EELS studies (*J. Shu, M. Backhause*)

v vs. G

Modeling thermodynamic work of fracture

For low temperature fracture process, constant oxygen concentration prior and after fracture is assumed.



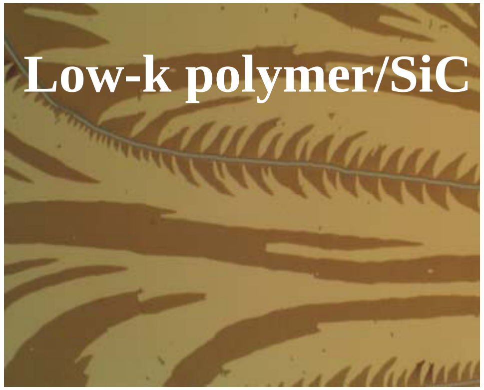
$$w_{Cu/O/Si3N4} = \gamma_{Cu(O)} + \gamma_{Si3N4(O)} - \gamma_{Cu/O/Si3N4}$$

By examining oxygen effects on surface and interfacial energy terms, we obtain:

$$w_{Cu/O/Si3N4} - w_{Cu/Si3N4} = -0.86\ J/m^2$$

-- fit experimental data.

Issues to be considered



1. Testing and modeling adhesion of new materials combination (polymer/dielectrics)
2. Thin film reliability at high temperatures

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